Reentrant BCS-BEC crossover and a superfluid-insulator transition in optical lattices

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I will discuss aspects of paired superfluidity in Feshbach-resonant Fermi gases in optical lattices[1,2]. Focusing on a deep optical lattice, I will show that for more than half-filled band the gas exhibits a reentrant crossover with decreased detuning, from a paired BCS superfluid to a BEC of molecules of holes, back to the BCS superfluid, and finally to a conventional BEC of diatomic molecules. This behavior is associated with the non-monotonic dependence of the chemical potential on detuning. This leads to a variety of interesting experimental predictions. For a single filled band a quantum phase transition from an insulator to a BCS-BEC superfluid replaces the crossover. The corresponding phase diagram is mapped out.